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LOCAL FORECAST MODEL:

PRESENT STATUS AND PRELIMINARY VERIFICATION

by

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Office Note 50

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INTRODUCTION

Work on the Local Forecast Model was begun at Suitland in late 1969 as a joint development venture by USAF Air Weather Service and National Weather Service personnel. The prospect of providing early guidance to forecasters from a limited-area, fine-mesh numerical forecasting model has been attractive to both services. The proposal would be to have the model operate at, say, two hours after the synoptic hour at which time sufficient data from the limited area would have been collected and reasonable initial values could be readied for the model. Boundary values would be provided by a previously run hemispheric, large scale model.

Additional benefits could be expected to derive from the better resolution of the LFM. The truncation error control in space should, perhaps, result in more accurate phase speeds and positioning of the smaller scale synoptic features. Analysis and balancing on a higher resolution grid may capture detail that would be lost in the operational (PEP) model. In particular, better initial depiction of the moisture parameters could conceivably result in better precipitation and sensible weather forecasting guidance.

THE MODEL

The Local Forecast Model (LFM) has been constructed in the same way as the operational model and, as a matter of fact, an effort was made to design the LFM to use as many of the PEP routines as possible. The equation systems and the basic physics of these models are the same and have been described in the article by Shuman and Hovermale (1968). The major differences will be described here.

Both models are designed to operate on a 3021 point rectangular grid. However, the LFM uses a grid length just half that of the PEP model; that is, the grid interval is approximately 190 km at 60° North latitude. In conjunction with halving the grid length, the LFM time step was also halved to five minutes to insure computational stability. The finer resolution of the LFM grid has made it possible to construct a model terrain which shows more detail than can be carried in the operational model.

The most difficult problems involved in making the LFM operable were associated with the boundaries of the grid. These boundaries, shown in the figure, are embedded in meteorologically active regions and the "wall" boundary condition of the operational model is inappropriate for the LFM. Boundary effects give rise to non-meaningful noise which creeps into the grid during the course of the forecast. To minimize these effects, boundary values are taken from an operational analysis, or an appropriate forecast, and then kept constant throughout the forecast run.

These and other actions have permitted the LFM to operate satisfactorily in the time range of interest.

Temperatures and heights are analyzed on the LFM grid to provide initial values for the model. Moisture, however, is analyzed directly in the sigma-coordinate system using a special scheme in which an attempt is made to preserve detail. The initial motion fields are gotten by balancing on the LFM with the same scheme used in the operational model.

METEOROLOGICAL EVALUATION

In order to test the LFM, an initial series of 30 test cases will be run and evaluated by NMC personnel. The first of these was run on October 26, 1970. To achieve a certain randomness, we attempted to run from 1200Z data each Monday. Because of scheduling problems on the computer, the run was left to be run overnight and then provided to NMC's Basic Weather Forecast Branch for their evaluation and comparison with the numerical guidance provided by the current operational forecast. Recently, a request has been made to the NOAA Computer Division to provide for a second run each week. A "case of the week" will be selected for running over the weekend to insure that some of the more interesting cases will be included in this test sample.

Additionally, an effort was made to take advantage of slack periods on the computers to run additional cases over the Christmas and New Year weekends. As a result, 16 cases of the series have been run so far and preliminary evaluations made. The long established S1 score for the sea level pressure charts have been calculated for the 24- and 36-hour LFM forecasts. Threat scores for occurrence of measurable precipitation over a 60-station net have been calculated as well. The NMC Quantitative Precipitation Forecast Branch have also calculated threat scores for occurrence of 1/2 and 1 inch precipitation. These results are presented in the tables 1 through 3.

In all of these statistics, it would appear that the LFM is certainly competitive with the operational model and perhaps has some advantage in the shorter ranges. Perhaps the most startling results are noted in the verifications of quantitative precipitation in which the LFM verifies nearly as well as the progs sent out over the facsimile net. Some individual cases of such charts are shown in figures 4a through 4d.

In addition to the statistical verifications, the individual forecasts have been subjectively evaluated. Again, it seems to be generally agreed that the LFM is entirely competitive with the operational model and that in certain cases shows some improvement which could have been exploited by the NMC forecasters. The operational model is really a very good one and is a difficult act to follow. The improvements are, as might be expected, associated with the placement and circulations in the smaller synoptic scale features.

Looking at an example, the last case that was run was from 12Z January 3, 1971 data, at which time a rather active storm was moving over the midwestern states. The operational model generally has a problem in moving lows out of the southern Rocky Mountain area. This is well recognized by the NMC forecasters and is referred to as "locked-in" error. The 500 mb and surface charts valid 36 hours after this initial time show this fairly typical lagging of the lows in the operational forecasts. The LFM forecasts depict the low positions further northward and nearer the verifying positions. The LFM is indeed slow, but has recovered more than half of the position vector error in this storm.

In another example, from 1200Z on Christmas Day, a surface low moved up the East Coast of the United States and provided some snow for the New England area. Again the operational forecast was slow, but in this case the LFM was too fast. However, the vector position error has been reduced. The surface low on the LFM forecast appears nearer the coast than is verified and may have resulted in a pessimistic forecast if it had been used as guidance. An example of detail that the LFM can provide is noted in the isobaric pattern over the Appalachian ridges, in which the trough is correctly depicted.

MODEL PERFORMANCE

The LFM, in this test series, has been programmed to make 36-hour forecasts. Of the 16 runs that have been made, four failed to reach the ultimate time and one other had questionable results. The four failures occurred at 31, 27, 26 and again at 31 hours. These can be attributed to boundary problems associated with strong flow which induces stratospheric exhaustion. Adjustments have been made to suppress some of the calculated tendencies of the various parameters near the boundaries. Four runs have been made with the new procedure, all of which went to 36 hours. In one of these latter cases, the model appeared to be quite dry. Investigation has pointed to a possible computer error in this case.

The LFM is a large, sophisticated numerical prediction model and it is expensive to run. At present, it takes about two minutes of central processor time per forecast hour to which the cost of initialization and post processing time must be added. The forecast code is optimized but the initialization code is not. The latter code has been constructed to operate in the changing environment at Suitland and is inefficient, but programming is underway to speed it up. The entire package now takes more than three hours of clock time to make a 36-hour forecast. Some improvement in this time requirement can be expected.

Table 1.

SEA - LEVEL PROGS

INITIAL DATE		CASE NO.	LFM 24-HR S_1	LFM 24-HR AVG. ERROR	LFM 36-HR S_1	LFM 36-HR AVG. ERROR	OPNL 36-HR S_1	OPNL 36-HR AVG. ERROR
Oct.	26	1	43.0	10.5	N.A.	N.A.		
Nov.	3	2	39.1	4.5	56.7	6.3	49.6	4.7
Nov.	9	3	43.4	4.5	N.A.	N.A.		
Nov.	16	4	49.0	4.4	64.2	9.7	75.2	4.0
Nov.	23	5	44.5	6.7	67.2	11.5	58.9	6.5
Nov.	30	6	41.6	6.4	55.3	10.5	68.4	6.6
Dec.	7	7	49.5	4.1	61.3	5.6	61.6	4.9
Dec.	15	8	51.4	4.9	54.6	6.5	58.6	3.9
AVG.			45.2	5.1	59.9	8.4	62.1	5.1
Dec.	22	9	51.3	5.0	N.A.	N.A.		
Dec.	25	10	52.6	9.2	62.4	17.0	75.0	7.0
Dec.	26	11	52.8	8.1	N.A.	N.A.		
Dec.	27	12	48.2	6.7	60.7	9.0	63.6	4.7
Dec.	28	13	57.4	7.3	56.3	10.7	77.7	7.3
Dec.	30	14	43.9	3.0	67.9	4.2	67.3	3.4
Dec.	31	15						
Jan.	3	16	59.4	5.9	72.1	7.4	73.8	6.1
AVG.			52.2	6.5	63.8	9.7	71.5	5.7

Table 2. COMPARISON OF FORECASTS OF PCPN IN 12 HR PERIODS (15 CASES)

	OPERATIONAL	LFM
0 to 12 HRS		
Tsp	.40	.50
P. A.	.50	.65
BIAS	1.31	1.07
12 to 24 HRS		
Tsp	.36	.39
P. A.	.55	.50
BIAS	.98	1.27
24 to 36 HRS		
Tsp	.36	.37
P. A.	.53	.50
BIAS	1.02	1.15

Table 3

12-24 HOUR FORECASTS

COMPARATIVE VERIFICATION OF NUMERICAL PRECIPITATION MODELS

(Oct. 27, 1970 - Jan. 4, 1971)

		F	O	C	T.S.	P.A.	Bias
A.	1.00 Inch						
	6-Layer	66.8	58.0	2.9	.023	.043	1.15
	LFM	121.3	58.0	22.7	.145	.187	2.09
	FAX	109.9	58.0	20.5	.139	.186	1.89
B.	0.50 Inch						
	6-Layer	228.6	233.2	67.7	.172	.296	0.98
	LFM	389.7	233.2	113.4	.222	.290	1.67
	FAX	356.5	233.2	115.4	.243	.324	1.53

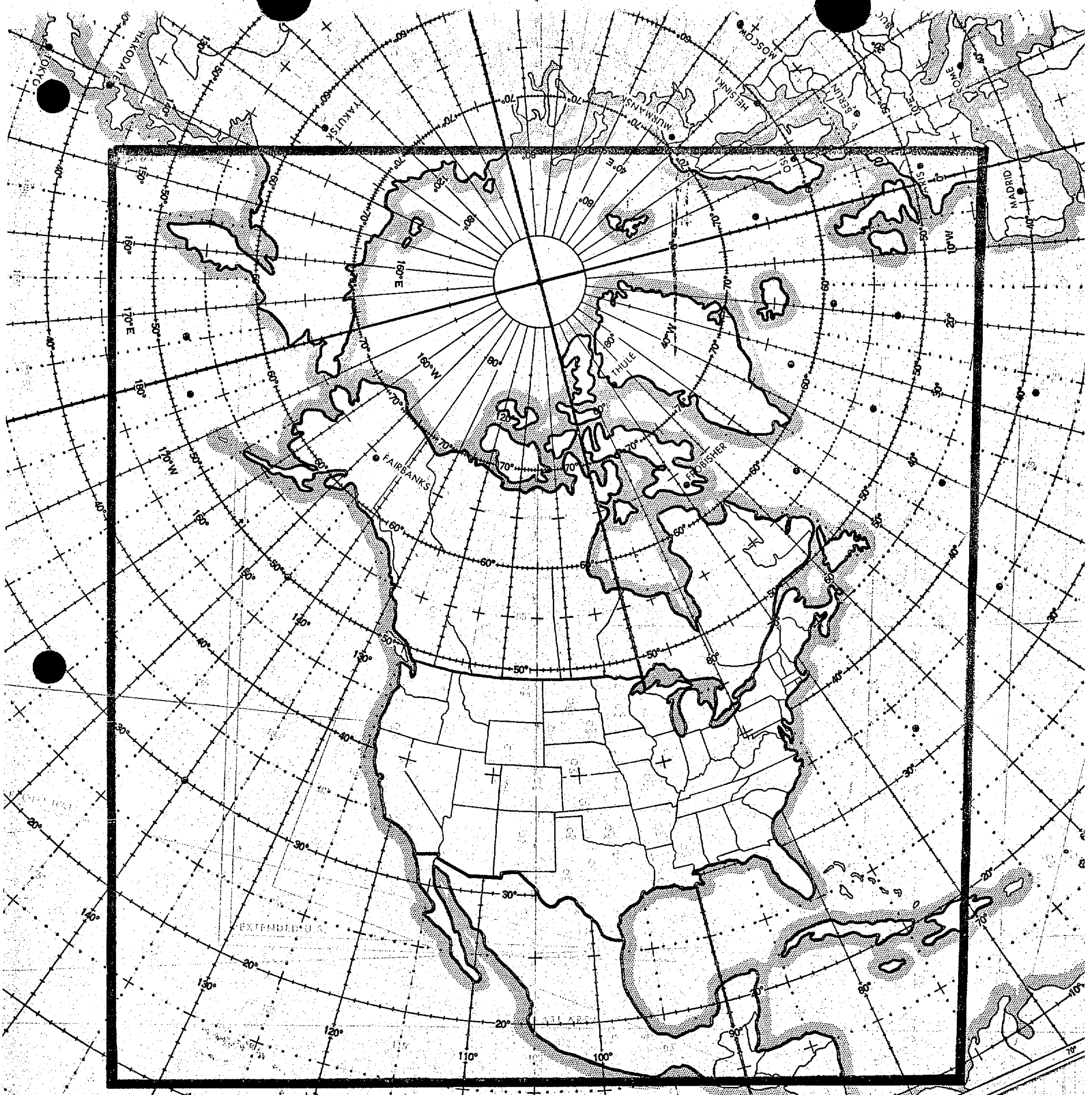


Figure 1. The Local Forecast Model Grid.

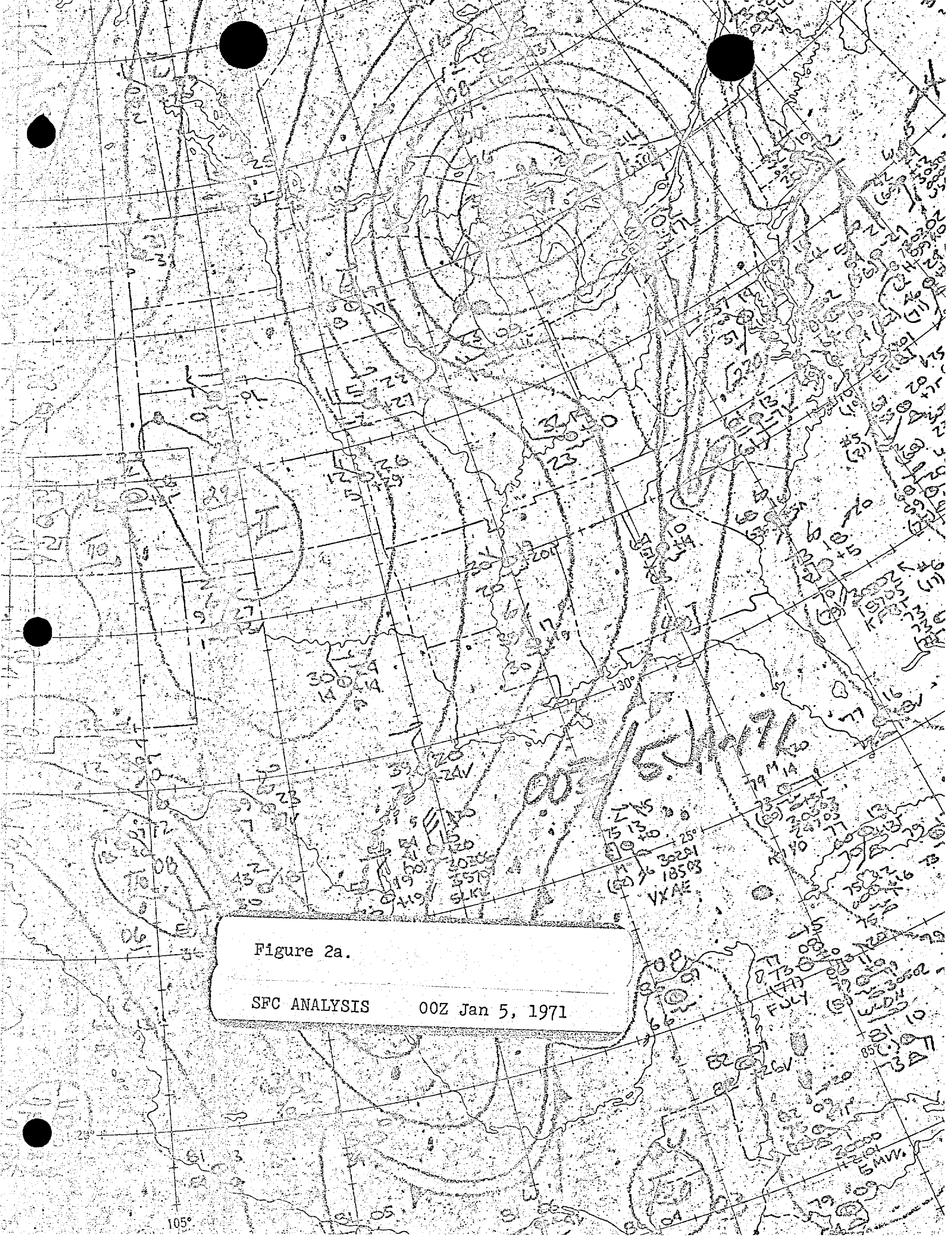


Figure 2a.

SFC ANALYSIS 00Z Jan 5, 1971

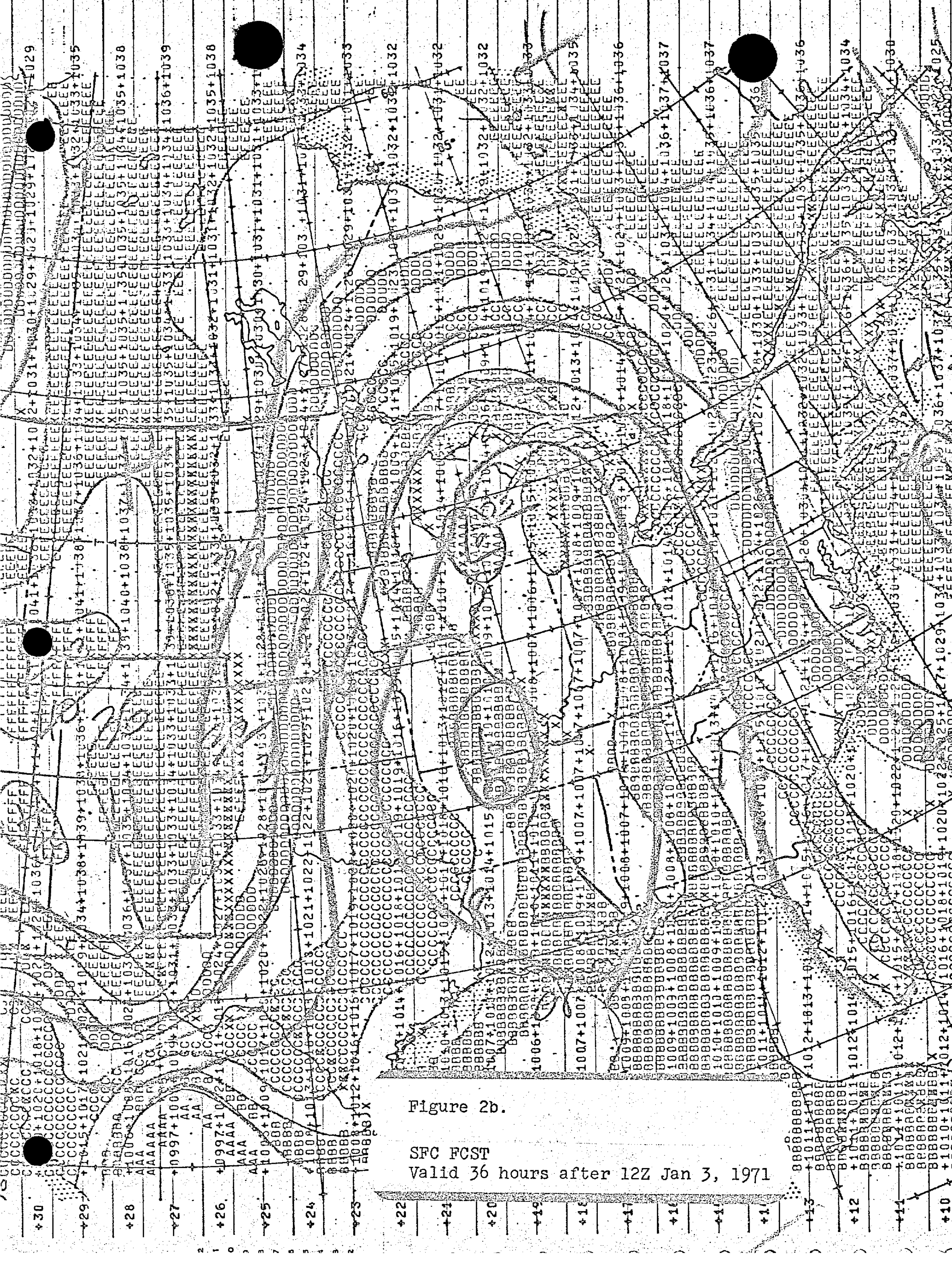


Figure 2b.

SFC FCST
Valid 36 hours after 12Z Jan 3, 1971

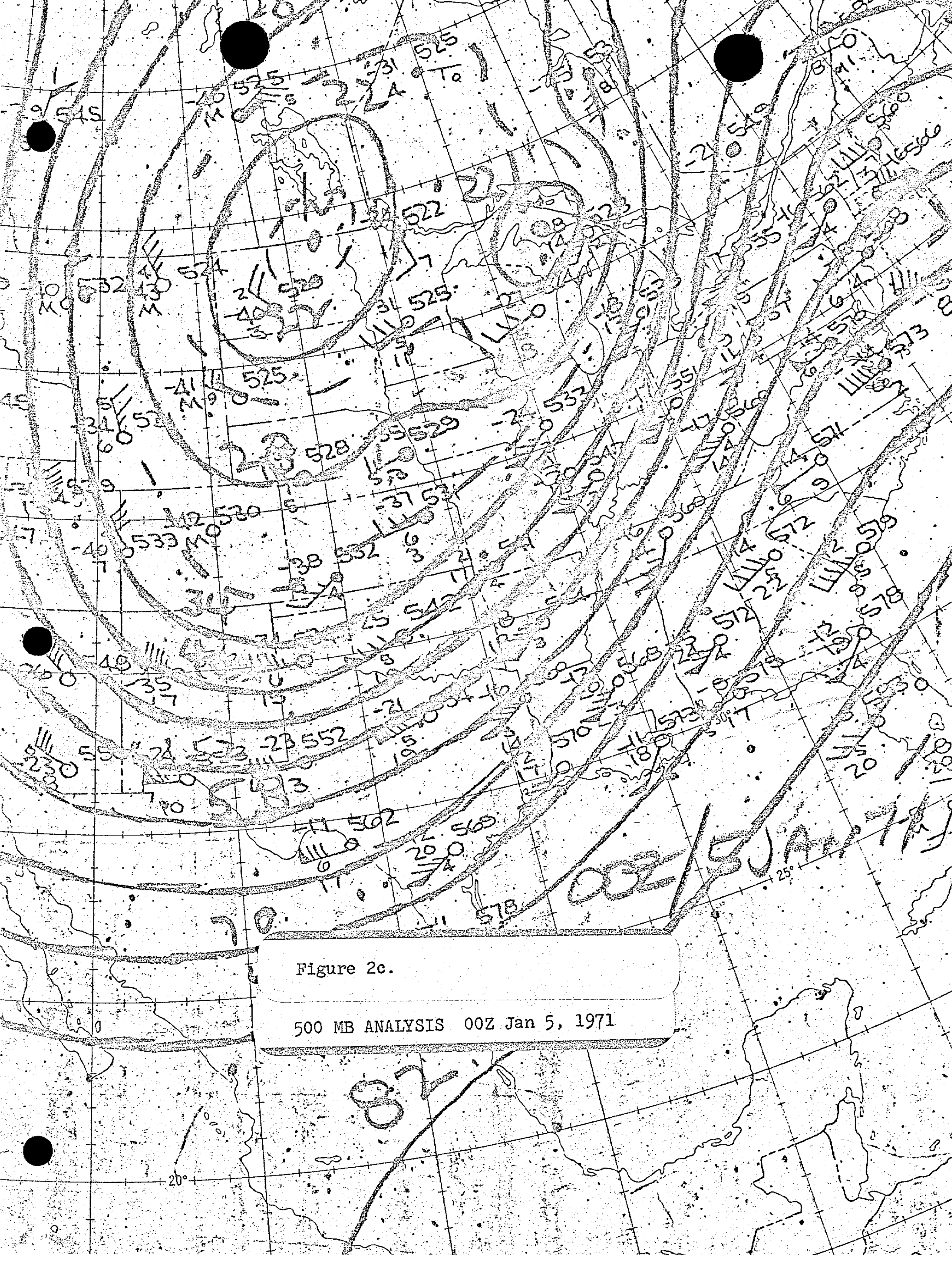


Figure 2c.

500 MB ANALYSIS 00Z Jan 5, 1971

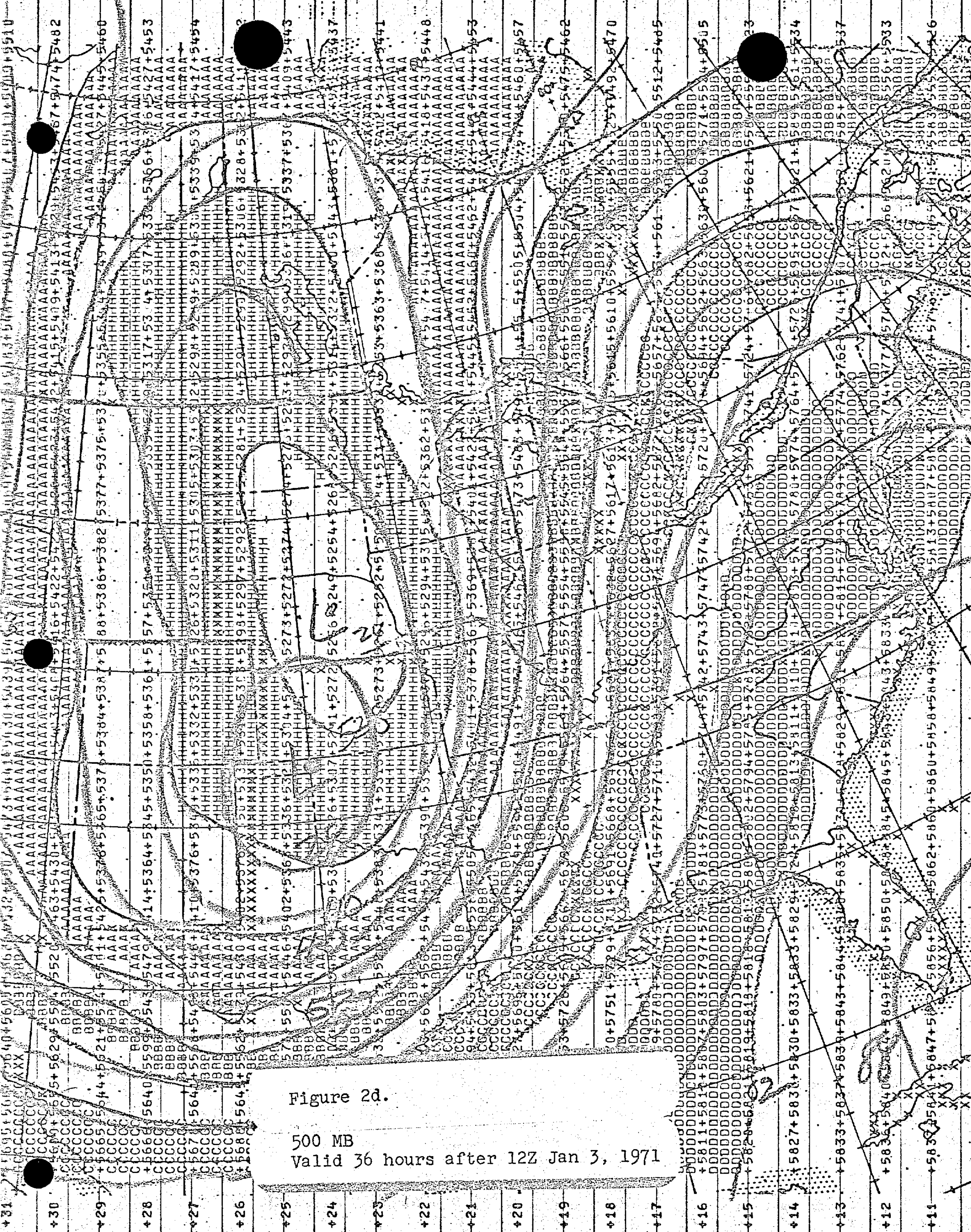


Figure 2d.

500 MB
Valid 36 hours after 12Z Jan 3, 1971

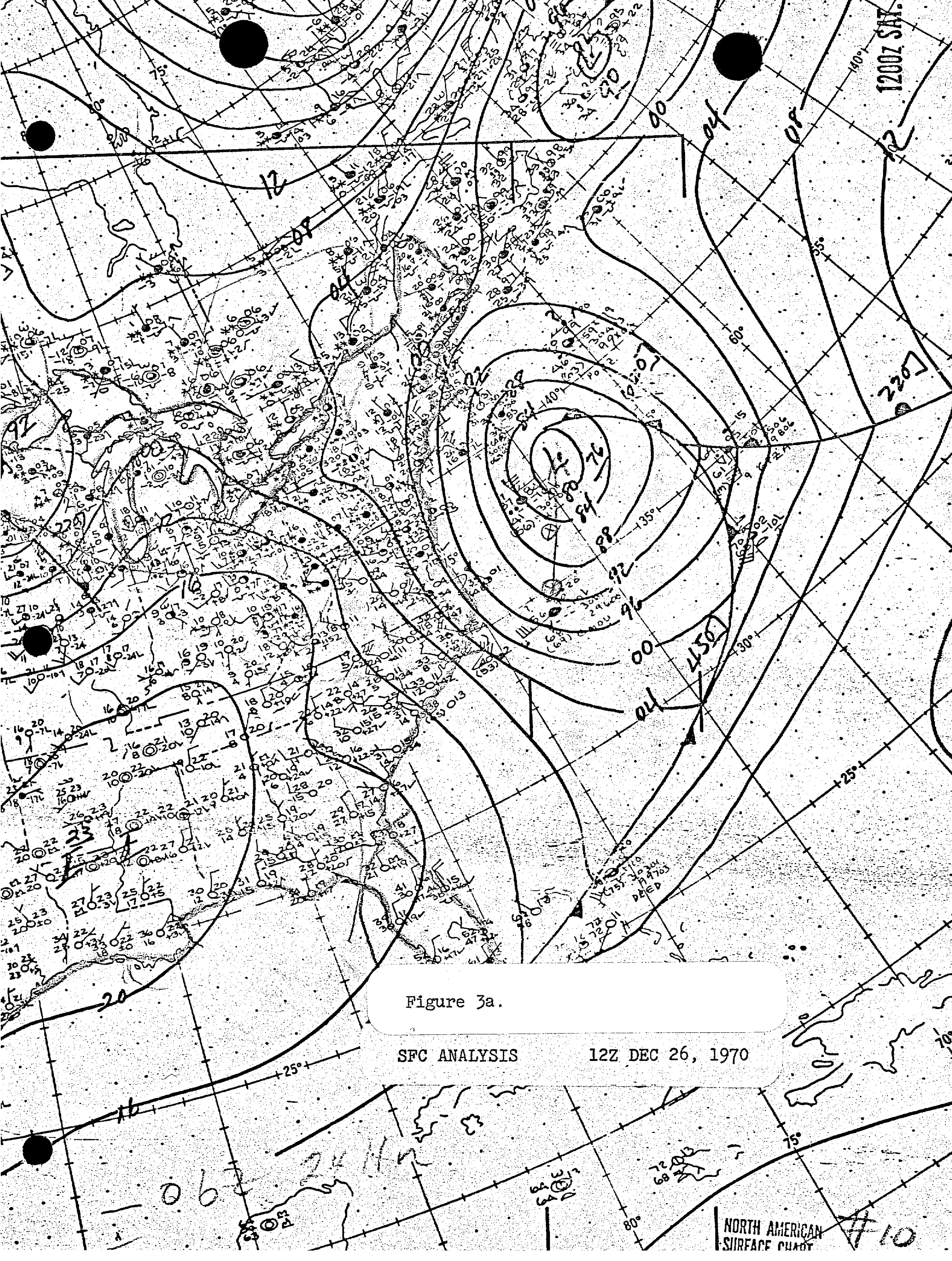


Figure 3a.

SFC ANALYSIS 12Z DEC 26, 1970

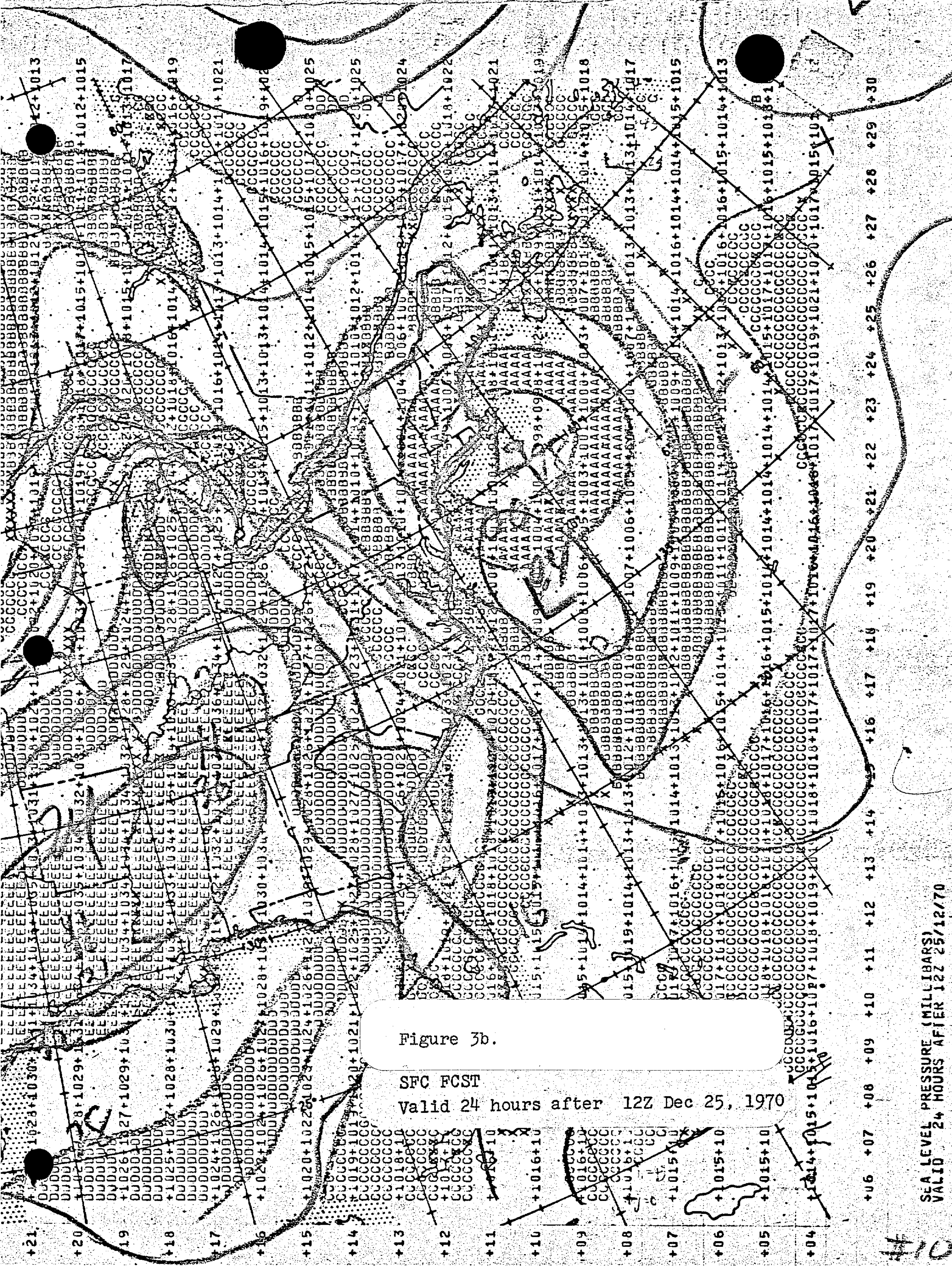


Figure 3b.

SFC FCST

Valid 24 hours after 12Z Dec 25, 1970

#10

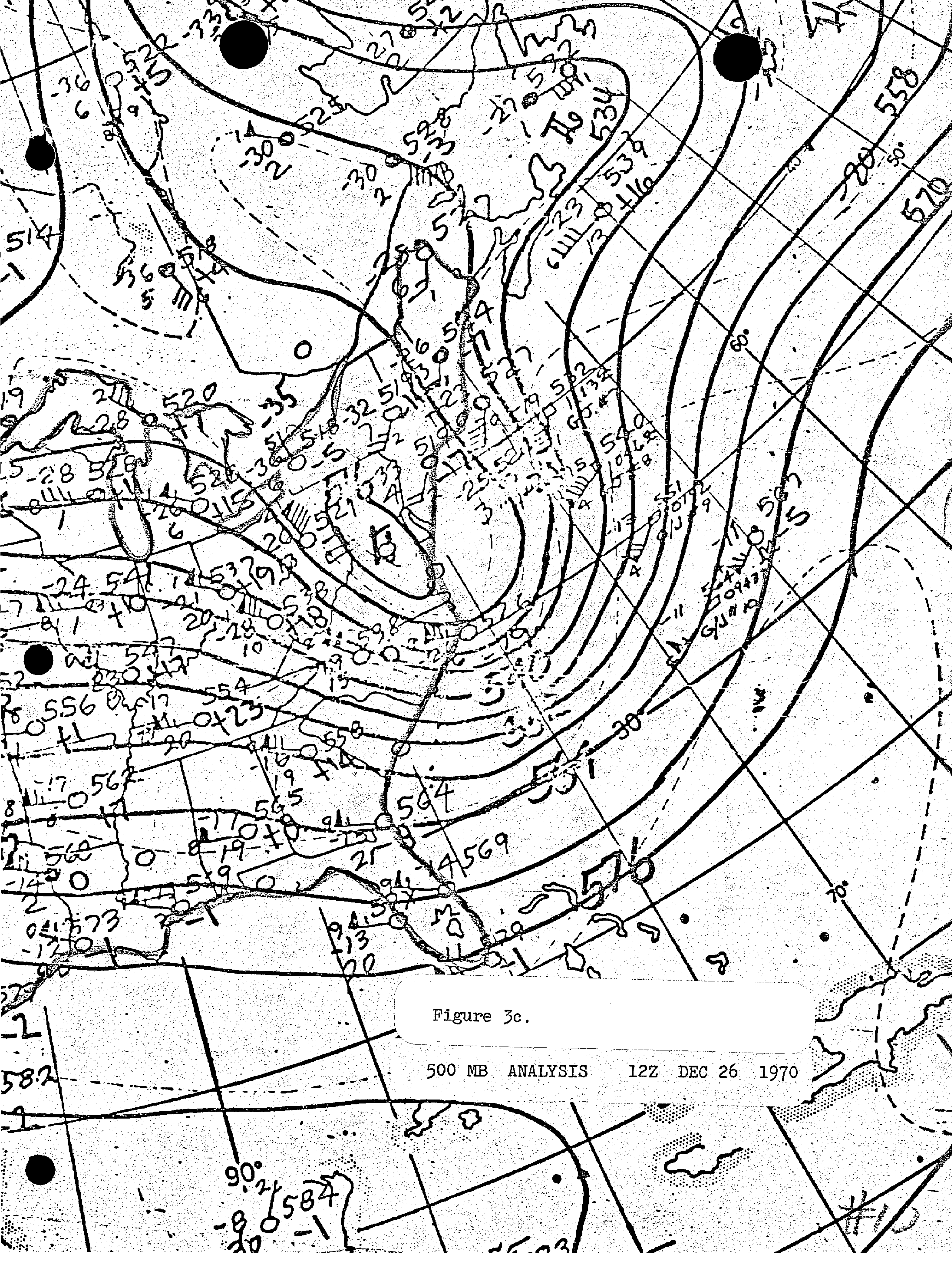


Figure 3c.

500 MB ANALYSIS 12Z DEC 26 1970

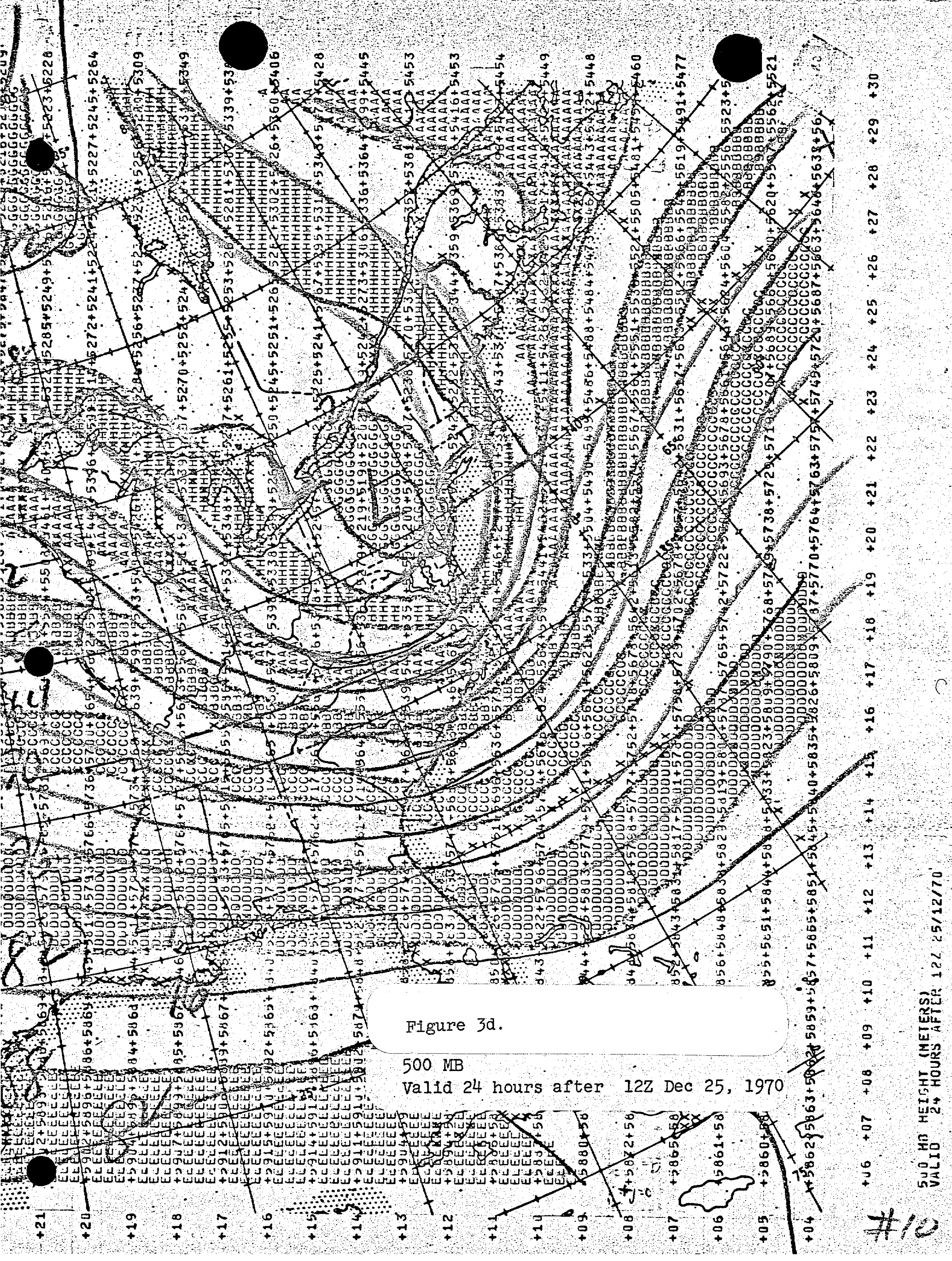
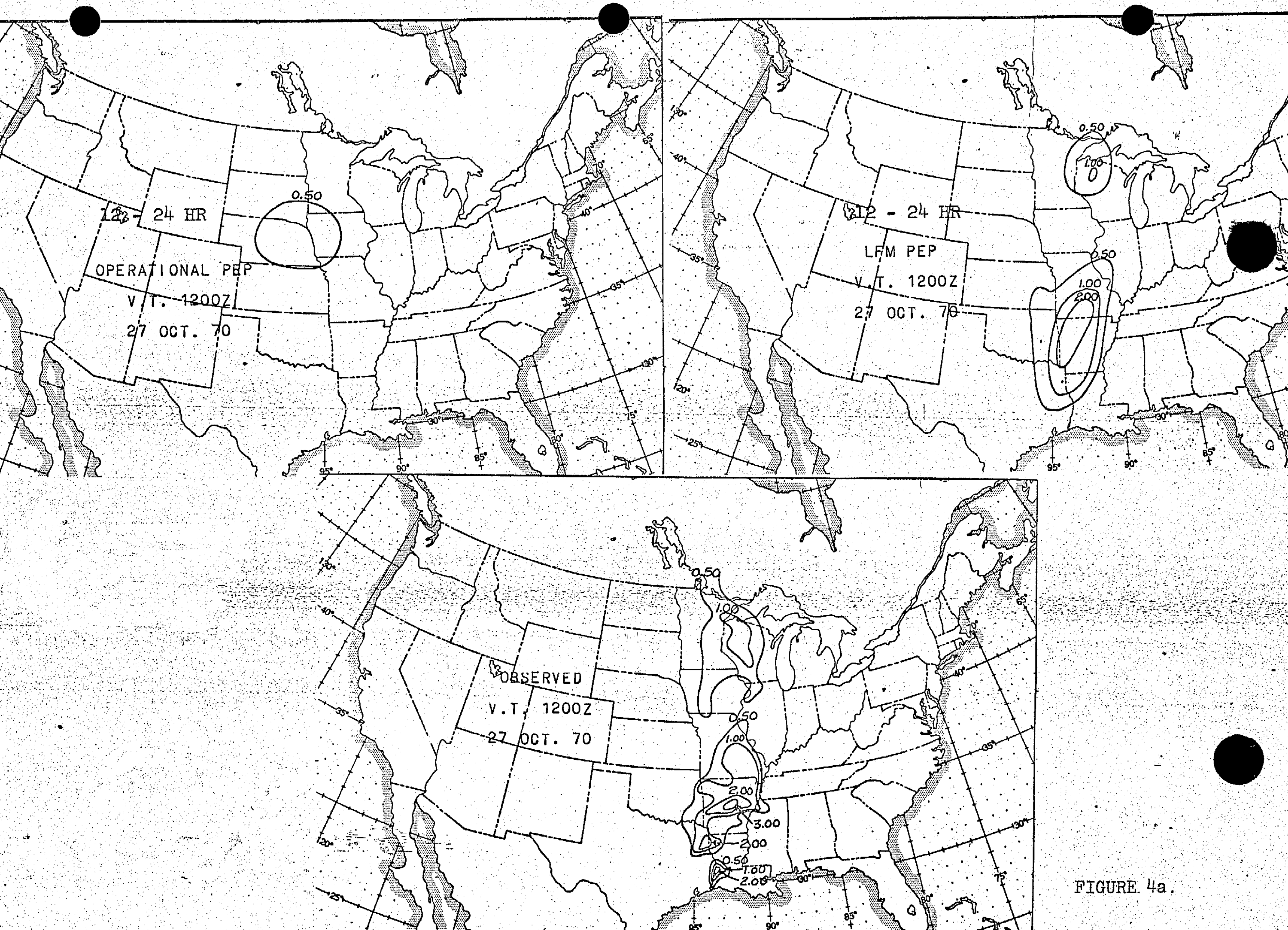


Figure 3d.

500 MB
Valid 24 hours after 12Z Dec 25, 1970

#10



12 - 24 HR
OPERATIONAL PEP
V.T. 1200Z
27 OCT. 70
0.50
12 - 24 HR
LFM PEP
V.T. 1200Z
27 OCT. 70
0.50
1.00
2.00
OBSERVED
V.T. 1200Z
27 OCT. 70
0.50
1.00
2.00
3.00

FIGURE 4a.

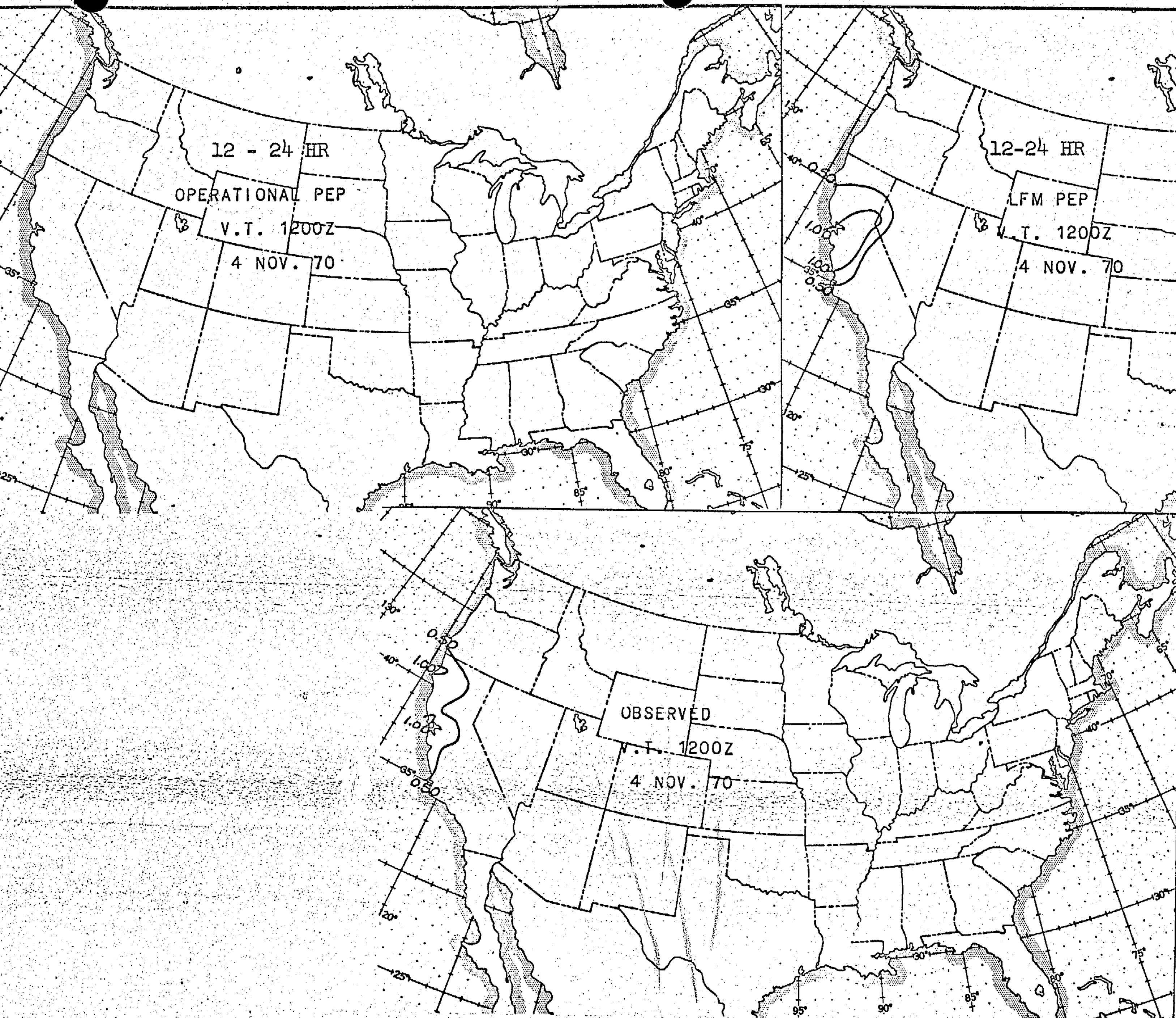

12 - 24 HR
OPERATIONAL PEP
V.T. 1200Z
4 NOV. 70
12-24 HR
LFM PEP
V.T. 1200Z
4 NOV. 70
0.50
1.00
1.00
0.50
OBSERVED
V.T. 1200Z
4 NOV. 70
0.50
1.00
1.00
0.50

FIGURE 4b.

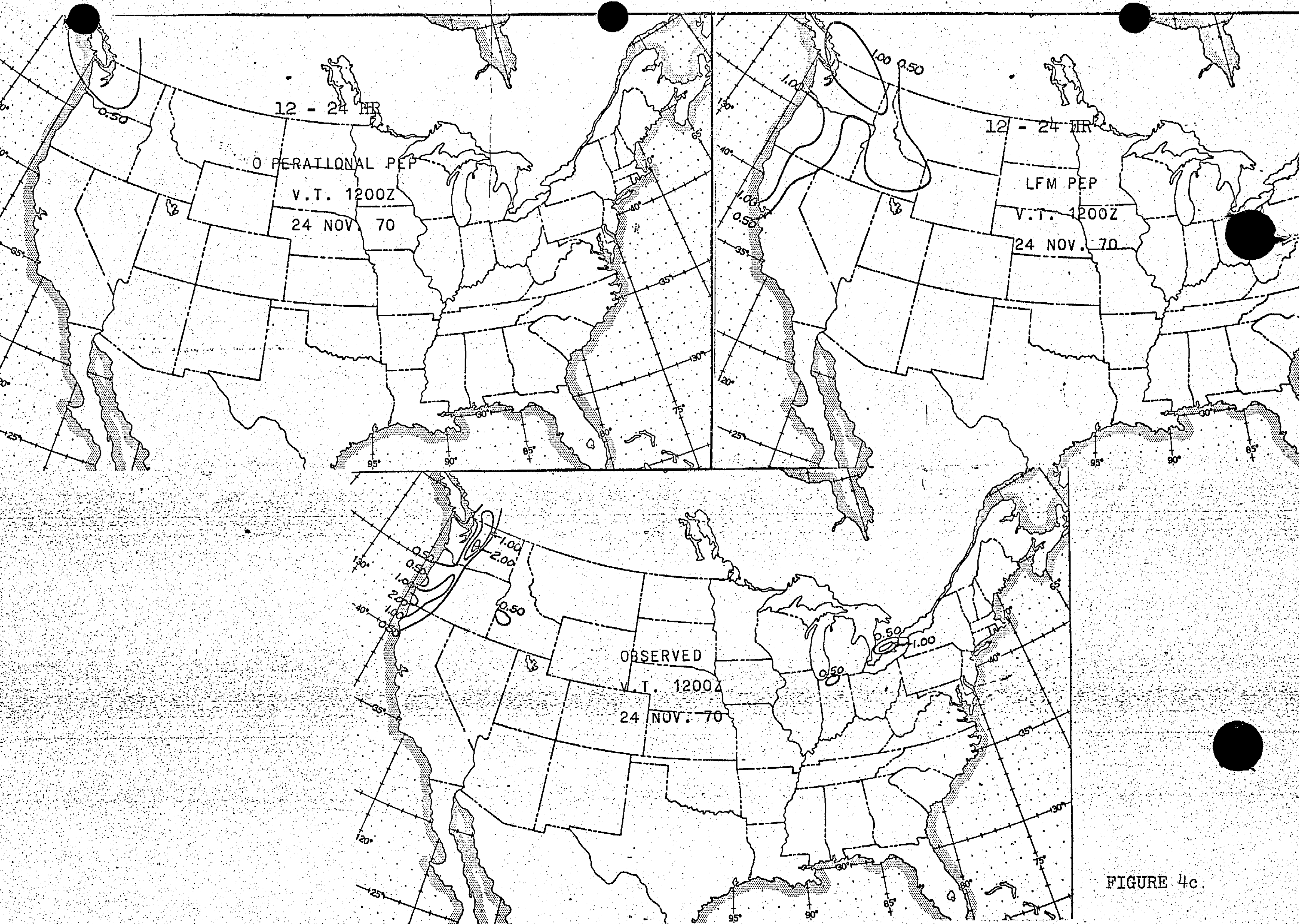
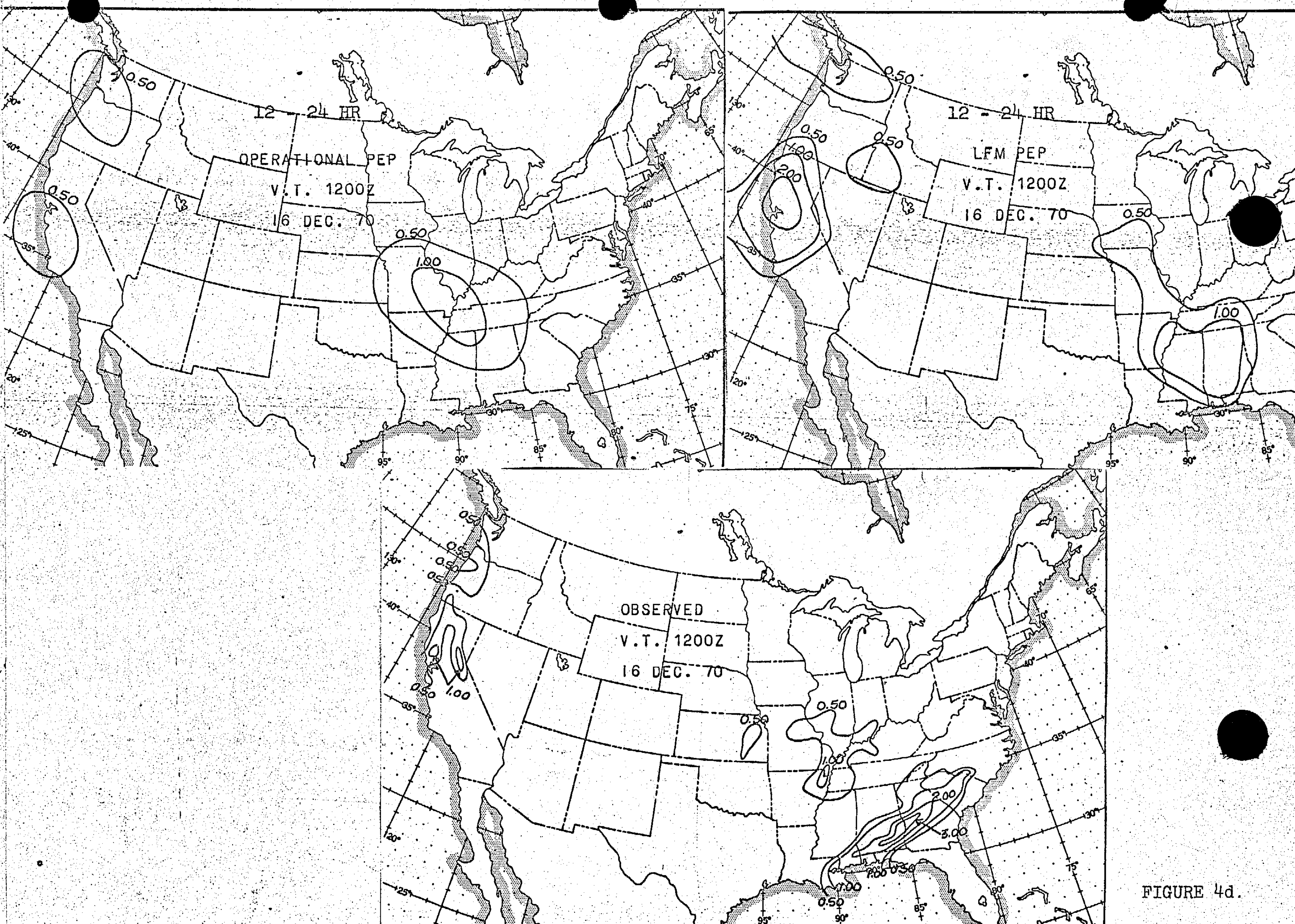

12 - 24 HR
OPERATIONAL PEP
V.T. 1200Z
24 NOV. 70
0.50
12 - 24 HR
LFM PEP
V.T. 1200Z
24 NOV. 70
1.00
0.50
OBSERVED
V.T. 1200Z
24 NOV. 70
0.50
1.00
2.00

FIGURE 4c



12 - 24 HR
OPERATIONAL PEP
V.T. 1200Z
16 DEC. 70
0.50
0.50
0.50
1.00
12 - 24 HR
LFM PEP
V.T. 1200Z
16 DEC. 70
0.50
0.50
0.50
1.00
2.00
0.50
1.00
OBSERVED
V.T. 1200Z
16 DEC. 70
0.50
1.00
2.00
3.00

FIGURE 4d.